SCIENCE:

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CORN CANE.*

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THE numerous varieties of maize now grown throughout the United States may conveniently be divided into a few general groups, easily distinguishable by the form and qualities of the grain.†

The most prominent of these are the Dents (white and yellow), Flint, Popcorn and the so-called sweet varieties. Since all sorts, however unlike otherwise, conform to the principle that the arrested development of the seed at the period above indicated, produces sugar accumulation in the cells of the stalk, and since it has been found that the sugar percentage is about the same in all at corresponding periods, it follows that the choice of the sugar planter, among the different kinds, must rest upon the most vigorous and well developed of the large-stemmed varieties that will mature their juice in any given locality. The people of our more northern States make a mistake in regarding the hard-glazed or "Flint" varieties of field corn, which are largely grown in that climate, as the best types of the species, naturally, and as bearing the best commercial type of the grain. Our western growers have already established a different standard, one which obtains now for American corn throughout the world and comes almost exclusively from the "Dent" group.

The best representatives of the species, both as regards vigorous growth and the nutritive qualities of the grain, are undoubtedly the large southern varieties, white and yellow. Maize is naturally a sub-tropical plant, but being an annual, ripening within a single season, our peculiar summer climate enables us to grow it to perfection under directly sub-tropical conditions; and in proportion as the Dent corn of the west and southwest approaches the southern type more closely in luxuriance of growth and the softer quality of the grain, does it increase in productiveness and nutritive value.

Among the different races of corn now existing the matured grain varies wonderfully, both in external qualities and composition, ranging from the "sweet" corn, with its permanently soft grain, richly charged with readily soluble food materials, on the one hand, to the "Flint" corn of New England on the other, yet the ear of the latter, in its immature stage, is but slightly different in composition and quality from that of the immature sweet corn.

It is not a little remarkable that this period of arrested development is the only period when the grain of all varieties may be said to have a common character. Experiments in stock feeding, as well as analytical results, show that it is then also in its most availably nutritious condition.

This stage now proves, also, to be a turning point in the life and economic use of the individual plant, when an alternative is significantly presented to the choice of the grower. The prompt separation of the ear at this stage conditions the full development of the sugar and the prolonged existence of the plant. But if the grain be allowed to glaze nothing can avert the almost immediate death of the plant and, excepting the seed, the destruction of the whole organized structure.

In the former case the result is equally certain and absolute. The saccharine development may be depended upon to go on until it has reached its limit, and it is as fixed and constant an attribute of the whole species as it is in the maturing joints of the sugar cane itself.

It remains for me only to indicate, in the briefest way possible, what is necessary now, practically, to make sugar manufacture a success from this new source.

First in importance is the answer to the question what varieties to plant that are best for this use. No one sort can be named which is equally well adapted for all localities, even in the main central corn belt of the United States. Everywhere in that region the period of juice-ripening is naturally brought to an end only by the frosts. Corn cane is nearly as sensitive to severe cold as the sugar cane, and throughout that region generally the aim should be to plant such varieties as will develop the milky condition of the grain by the 20th of August, so as to insure a period of two weeks for sugar accumulation by the first week in September, when the manufacturing season for the main crop would regularly begin. The following well-known sorts sufficiently matured their juice last season early in September, and most of them can be recommended for this use from Ohio westward and southward, ranking them in that region in the order named:

1. Large Southern White or Virginia fodder corn.
2. Burpee's Golden Beauty, a highly improved and well established variety of the yellow Dent.
3. Chester County Mammoth.
4. Kansas Yellow Dent.
5. Early Mastodon Dent.

The first named is the best ensilage corn grown, and wherever it will mature its ears to the roasting ear condition in August it will have the preference in sugar manufacture on account of its great productiveness and the richness of its juice. Golden Beauty has been tested from the outset of these experiments in 1884, and with the very best results. Like all the rest named, its stems are very robust, well developed stalks when trimmed weighing three pounds.

After these, but not ranking with them at all in productiveness, Stowell's Evergreen-Egyptian and Mammoth Sugar, among the sweet corn group, may be named. Their juice is not superior to that of field corn in any quality. I have no question that by selection and inter-crossing a variety of sweet corn will yet be produced which will be as productive of grain for canners' use as any that we now have and equal to the field varieties in robust stem-growth. For the sugar crop, no special preparation of the soil is needed other than is commonly required to produce a heavy crop of field corn. The seed should be sown in drills three and a half or four feet apart, and thickly enough for the plants to stand about ten inches apart in the row.

*Continued from Science, Sept. 22.

†Dr. E. L. Sturtevant, while in charge of the New York Experiment Station, corrected the nomenclature of maize and originated a system of classification, deriving the distinctive characters from [illegible] the structure of the kernel or grain. The arrangement seems to be a natural one otherwise, and his definitions of the varieties then existing are very valuable now for purposes of identification, although some new ones have originated since then. (N. Y. State Expt. Reports for 1883 and 1884.)

Experiment has proved that a yield of fifteen tons per acre of trimmed cane from the large southern corn is, under these circumstances, an average result.†

The use of bone phosphate, and especially nitrate of potash, applied in the hill as fertilizers, is strongly to be recommended. Also, the best labor-saving implements should be employed in the cultivation of the crop. These have so far proved their value as to have reduced the cost of corn-growing within the past twenty years by about fifty per cent.

The ear should be allowed to develop until the grain has reached the "milky" stage, but never in the least beyond it, and when field corn is grown, first the ears in the husk, and subsequently when the stalk is cut, the tops, leaves and other offal should be passed through an ensilage cutter and treated precisely as ordinary ensilage. Or, when special facilities have been provided for it, the grain on the cob, with the husk removed or not, may be kept apart by itself, and after being coarsely crushed, or cut into small pieces, may be fed in that condition or dried and ground as feed for stock. In this form it is much superior for cattle food to the ordinary corn and cob meal.

To facilitate the removal of the ears the corn field, when planted, may be laid out in lands or sections of about eight rows in each, with an interval of about five feet between the outside rows of adjoining sections, so as to admit of the passage of a short-axled cart drawn by a single horse or two in tandem to carry off the grain. This will be done, and the ears in the husk properly cut and stored in the silo, or dried and ground, before the sugar season has properly begun.

At this time it is important that every vestige of an ear should be removed from the stalk; and, thenceforward until they are cut to avoid injury from frost, every day adds to the accumulation of sugar in the cells of the standing canes. But in climates where the growing season is short, or, as sometimes occurs further south, unusual cold sets in early in the fall, it is better to avoid the risk of injury to the crop by harvesting it about two weeks after the removal of the ears, when the juice will have attained a density of about 8° Beaumé, containing about thirteen per cent of cane sugar.

†Trustworthy evidence that this yield of corn cane per acre from the large-stemmed sorts is below the average is furnished in the reports from the different State Agricultural Experiment stations of the yield for ensilage when accurately weighed. Up to the period at which it is usually cut for that purpose, the conditions of growth are essentially the same as when sugar-growing is the ultimate object.

At that stage an average of about twenty-five per cent must be deducted from the gross weight of green ensilage for the weight of the immature ears, blades and tips. The remainder is to be estimated as trimmed cane.

Some examples are given below of the yield in districts well known to be less favorable for the growth of the large, late sorts than the more central parts of the corn belt.

Yield per acre:

43,700 lbs. (21.85 tons) southern "Ensilage" corn, 42,060 lbs. (21 tons) southern "Horse Tooth."—Prof. W. A. Henry, Wisconsin Ex. Sta. Report, 1891.

50-60 tons "Southern Fodder Corn," 32 tons "Mammoth," 30 tons "Southern Horse Tooth," Native Yellow Flint, only 15-20 tons.—New Jersey State Expt. Sta. Rep., 1881.

27.37 tons "Orange Flint."—N. Y. Ex. St. Rep., 1885.

40 tons "Southern" corn and "Blount's Prolific."—J. J. H. Gregory, Marblehead, Mass.

29 tons "Southern" corn.—T. S. Peer, Palmyra, N. Y.

30 " " " J. J. Chaffie, Passaic, N. Y.

27.5 tons "Blount's Prolific."—F. E. Loud, Weymouth, Mass.

46 tons or 600 tons on 13 acres.—Clark W. Mills, Pompton, N. J.

50 tons "Kentucky White."—Geo. L. Clemence, Southbridge, Mass.; quot. H. J. Stevens on ensilage.

25 tons per acre on 15 acres.—F. R. Coit, Mantua Sta., O.

20 to 25 tons "Penna. Dent."—Ralston Bros., Elderton, Pa.

If properly stored so as to be screened from the sun and rain in a cool place, the canes can be worked up within about ten days after cutting without appreciable loss. But if warm weather prevails, the interval should be as short as possible between the time of cutting and working up.

The internal structure of the corn stem is peculiar, so much so as to make the extraction of the juice from the canes by the ordinary sugar mill practically impossible. These structural peculiarities, as disclosed by the microscope and as evidenced by numerous practical tests for the extraction of the juice, make it plain that other means must be resorted to than pressure between revolving rolls to extract the cell sap.

Corn cane yields to pressure much more readily than the sugar cane or sorghum, but the elasticity of its tissues is such and the recovery so sudden after passing the line of pressure that fully one-half of the expressed juice is mopped up before it can leave the roll or the guide plate and is re-absorbed.

No other plant is capable of being exhausted of its cell contents more rapidly or thoroughly by diffusion; but the expense of that process is very considerable and its inconvenience very great. It was seen that the economy and efficiency of any system of sugar making from this plant must depend largely upon the construction of a machine which would separate the juice expeditiously and without waste. It was at last found that a sufficiently simple apparatus could be constructed by which the benefits of both milling and diffusion could be secured without any of the prominent defects of either system when separate. Special mention is made here of these facts for the reason that the only practical difficulty peculiar to this plant, in the extraction of its sugar, is thus easily overcome.

Sugar making from this or any other plant is both a science and an art, and the general principles upon which it depends are now well understood. The composition of the juice of corn cane is somewhat peculiar,‡ but not sufficiently so as to require any considerable deviation from the best systems of sugar manufacture now in vogue for the treatment of the raw juice of the tropical cane.

I conclude this sketch with a brief summary of the results reached, leaving the intelligent reader to draw his own conclusions. But it must be said, that if we would now reach any just estimate of the saccharine value of maize, in this new role, we must remember that all previous attempts to determine it were made without any knowledge of the important physiological principle upon which that value solely depends and which this investigation has now disclosed.

From a system of treatment which takes advantage of this in a practical way it follows:

1. That the highest normal of sucrose or true cane sugar in the juice, seven to eight per cent, is raised to thirteen to sixteen per cent, or almost doubled.

2. This is accomplished by a true juice-ripening process, analogous in all respects to that which marks the maturing sugar cane. It is natural to the plant under the changed conditions and is constant in all varieties of the species.

3. Its rank as a sugar-producing plant, under these circumstances, having thus been accurately determined, and a wide range of experiments undertaken to test the practicability of sugar extraction having proved that no hindrances thereto exist that are at all comparable to those met with in the case either of the sugar beet or of

‡Corn cane juice contains an organic acid previously detected only in corn silk (maizenic acid). A peculiar protein body Zein long ago found in the grain, is also found in the juice, together with several others not thoroughly investigated.

sorghum, the chemical constitution of its juice approaching more closely that of the tropical sugar cane than any other, the term *corn cane* here used to distinguish the plant when in this condition of development will, I trust, not seem to be misapplied.

4. The utilization of the plant in this way is the most thorough and perfect possible, because it takes advantage of the fact that the development may be so controlled as to secure from the same individual plant at two different periods of its existence: first, the grain product, when in its most nutritive and assimilative condition to serve as feed for animals, or as bread food, and second, and conditioned upon the first, a matured condition of the highly organized substances in the cells of the living stalk, and their safe storage there for an indefinite time, a full crop of sugar being thus easily attainable as the result.

5. No risk is run by the grower in producing corn cane, because it is at his option, up to an advanced stage of its growth, to choose whether he shall harvest it as a grain and sugar crop combined, or as ensilage simply, or as the ordinary product, the hard ripe grain.

6. To secure a healthy and luxuriant growth and a full crop of any of these products the requirements as to climate, soil, tillage, the use of fertilizers, etc., during the true growing period, are almostprecisely the same in all cases. No new system of agriculture is necessary to be inaugurated to make sugar-growing at a profit a success, no new plant is to be acclimatized before its merits can be tested, but following a system of culture with which we are familiar, making one simple but radical change only in the routine, we have practically a new plant in the new uses that it serves.

7. It follows from this that the cost of sugar-growing from this new source, ought to fall much below the average cost of producing it from any other plant. This is still more evident if we consider that the sugar crop from corn is capable of being brought to full maturity in a relatively short period, as compared with either that from the sugar cane or the beet; that a ton of trimmed corn-cane, bearing at least as high a sugar percentage as the sugar beet, can be grown here at about one-half the cost of a ton of beets, not counting the immature grain and fodder ensilage produced along with it. The latter represents an added value almost equal to that of the sugar for which the sugar cane furnishes no equivalent whatever, and neither the beet nor sorghum any that will bear favorable comparison with it.

8. The enrichment of the juice of the corn plant grown for ensilage alone, or for use as dried fodder, secured by the timely removal of the ears and the curing of that part of the crop separately, is of scarcely less general importance than when sugar-growing is the main object.

9. It is evident, also, that the full limit of this enrichment has not yet been reached. The capacity of Indian corn, for rapid improvement through judicious selection and hybridization, gives promise of securing new races possessing still more valuable qualities for sugar production than are found in any now existing.

10. Among the benefits which the establishment of the sugar industry from maize will confer upon American agriculture, a prominent one will be to check over production of the hard-ripened grain. When it is known that from the same plant equally valuable products in other forms are regularly attainable, which, being substituted for the ordinary staple, will secure the benefits of a wholesome limitation to the production of the latter, the area devoted to the growing of the plant will profitably be enlarged to any extent to meet the enormous capacity of our western soils to produce it.

In giving to the public these conclusions it is, perhaps, scarcely necessary to add that the motive of this investigation was simply to fix the value of maize, under the new conditions, as a sugar-producing plant.

Table:—Relative composition of the juice of "corn cane" and sugar cane.

	Indian Corn.								East India Sugar Cane.* Carefully sampled good average cane. Aska Dist., Madras. (Gill.)			Louisiana Sugar Cane.† Magnolia Plantation. (Wiley.)			
	Period of Early Growth.				Period of Saccharine Development.										
					"Southern Fodder."		Penna Yellow Dent.	Golden Beauty.							
	In Tassel.	In Silk.	In early roasting ear.	Ear removed.	One month after removal of ear.			54 days after ear removed.	2 feet of top.	2 feet middle.	2 feet next root.	Mean of 4 years. 1884.	1885.	1886.	1887.
Specific gravity	1012.6	1034	1048	1056	10674	1071	10692	10694							
Cane sugar	0.	2.90	6.70	10.32	13.90	14.94	14.68	14.63	11.51	14.55	14.58	13.05	12.11	13.50	13.69
Glucose	1.87	3.00	2.50	1.90	1.61	1.16	1.08	1.04	2.86	1.65	1.68	0.67	1.02	0.61	0.77
Organic matter not sugar, and ash.	1.13	2.80	1.80	1.18	0.91	1.20	1.14	1.25	0.83	1.20	0.74	2.82	2.67	2.09	1.81
Total solids	3.00	8.70	11.00	13.40	16.42	17.30	16.90	16.92	15.20	17.40	17.00	16.54	15.80	16.20	16.27
Water	97.00	91.30	89.00	86.60	83.58	82.70	83.10	83.08	84.80	82.60	83.00	83.46	84.20	83.80	83.73

*Gill's analysis, quoted from Allen's Organic Analysis, Vol. 1, p. 261. (1885.)
†U. S. Department of Agriculture, Bulletin 18.—Wiley. (1888.)

Disparagement of the earnest efforts that have for many years been made, and are still being made, to make beet sugar growing in this country successful, has not been thought of. But it must be remembered that every industry dependent upon plant growth and development for its existence must have due respect to the peculiar conditions of climate and soil prevailing in the country where it is proposed to establish it. It is now well known that the climatic limits of successful maize-growing on this continent are very wide, and those restricting the beet for employment in sugar manufacture are quite narrow. Here, as elsewhere, the foundations of success are laid in natural laws. And one thing seems clear: the typical sugar plant for America must be one possessing the robust health and all the qualities which are supposed to spring from being "native and to the manor born," and which, while meriting and needing, perhaps, the fostering care of the home government as the basis of a new industry, at the start, yet must prove its ability to stand alone, unsupported by a bounty or any other merely adventitious aid.